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EVALUATION OF PLOTS USED DURING MOUNTAIN PINE BEETLE SURVEYS

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In 1967, entomologists and foresters in the West began conducting surveys in lodgepole pine (Pinus contorta Dougl.) forests to assess losses caused by the mountain pine beetle (Dendroctonus ponderosae Hopk.). Strips, fixed radius, and variable radius plots were utilized in systematic sampling designs to obtain loss estimates. Subsequently, questions were raised concerning the relative statistical precision and field measurement efficiency of each type of plot.

Knight and others (2) compared the 1/10-acre fixed radius plot with both larger and smaller fixed radius plots and with strips of various widths, all measured with one-man crews, for estimating the number of Engelmann spruce beetle (Dendroctonus rufipennis (Kirby)) attacks in Engelmann spruce (Picea engelmannii Parry) stands. They found the statistical efficiency of the 1/20-acre fixed radius plot was about the same as for the 1/10-acre plot size, but that it was more economical to measure. However, the 1/10-acre plot was still recommended because few additional 1/20-acre plots could be sampled per day and fewer zero counts on plots resulted with the 1/10-acre plots. Fixed radius plots larger than 1/10 acre were tested, but they were reported to be inefficient in dense stands. They concluded that strip plots, as narrow as 1/2-chain wide, were difficult to sample because a cruiser had to run a compass line, pace distance, and check for attacked trees at the same time. However, Knight (1) compared 1/10-, 1/5-, and 1/4-acre fixed radius and 1/2- and 1-chain-wide strips in a simulation study for measuring mountain pine beetle-caused losses in ponderosa pine (Pinus ponderosa Laws.) stands and recommended the 1/2-chain-wide strip. He found that all plot types had about the same degree of precision, but the 1/2-chain-wide strip and 1/10-acre fixed radius plots were more efficient to measure.

Stage (6) compared variable and fixed radius plots for estimating basal area and concluded that a 10 BAF variable radius plot was more efficient than 1/5- to 1/50-acre fixed radius plots in small diameter lodgepole pine stands. Also, he indicated that fewer plots and fewer trees per plot were needed to attain equal statistical precision. Trials by Shanks (5), Larson and Hasel (3), and Lindsey et al (4)--as reviewed by Stage (6)--have shown that variable radius plots yield more stand information for a given cost. We were unable to find any information comparing fixed radius with variable radius plots in regard to measuring the number of trees killed by bark beetles.

To provide a coordinated evaluation of plot alternatives (including variable radius plots) for estimating lodgepole pine losses caused by the mountain pine beetle, a study was conducted to evaluate the following kinds of plots: Variable radius plots, 5 and 10 BAF; 1/10-acre

fixed radius plot; and 1/2-chain-wide by 10-chain-long strips (1/2 acre). Two-man crews were used exclusively in an effort to reduce measurement errors.

METHODS

The study was conducted on a 160-acre lodgepole pine tract (40 by 40 chains) in the Warm River Area of the Targhee National Forest (Figure 1, Appendix). Three of the four corners of the study area were located on section or quarter section corners. The fourth was established using a topographic trailer tape. The boundaries were marked with flagging and paint lines.

Initially, a 100 percent cruise was conducted to record all of the insect killed or infested trees in the study area. One- to two-chain-wide strips were marked by string lines and crews recorded trees by 2-inch diameter classes on the strips. For checking purposes, dead trees recorded during the inventory were blazed. Every effort was made to minimize cruiser errors, but "missed" trees were discovered at later stages in the study. We were unable to relate the number of trees missed during the inventory to an area basis for an evaluation of accuracy.

Sixteen variable radius and fixed radius plots were systematically located at 10-chain intervals along four cruise lines distributed over the study area (Figure 1, Appendix). Strip plots were established along the same four cruise lines. The length of each strip plot (10 chains) was measured with a trailer tape. A Spiegel-Relaskop was used to record "count" trees on the variable plots. Boundaries of fixed radius and strip plots were measured with a 75-foot metal tape and slope correction measures were used when necessary.

RESULTS

There were no appreciable differences in the estimated numbers of trees per acre killed or infested by the mountain pine beetle for the four plot types; nor were there detectable differences in their standard deviations (Table 1, Appendix). However, the efficiency of plot measurement was greatest for the strip plots. Plot measurement times were not recorded in the same study area, but in a nearby lodgepole pine stand (plot layout, terrain, and intensity of dead trees were very similar). The average time required to walk the 10-chain distance between variable and fixed radius plots (8.7 minutes) was added to plot measurement times to make them comparable with the strip plots. An average measurement time per tree was obtained by dividing the average number of trees recorded per plot

by the average measurement time. The measurement time per tree was less for the 1/2-acre strip plots than for the other plot types (Table 2, Appendix).

In addition, the distribution of beetle-killed trees by diameter class, estimated from the 1/2-acre strip cruise, more closely approximated the distribution of dead trees recorded during the 100 percent cruise (Figure 2 and Table 3, Appendix). To numerically assess the differences in the distribution of trees by diameter classes, the total number of trees per acre for each plot type was expanded to a common mean (30.55). Then, the equally weighted number of trees per acre were distributed by diameter class within each plot type in proportion to their original occurrence. Departures of the adjusted numbers of trees per acre by diameter class within each plot type from those of the complete tally cruise were totaled (Table 4, Appendix). The sum of the departures for the 1/2-acre strip cruise was approximately half of totals for the other plot types. The 1/2-acre strip plots apparently yielded a more representative distribution because more trees were recorded, but more time was required for plot measurements.

SUMMARY

We were unable, in this study, to detect a statistical advantage for any of the plot types tested, but the 1/2-acre strip plot appears to be more efficient in terms of plot measurement and has a lower sampling cost per tree. Further, the 1/2-acre strip plot can be used to advantage if a representative distribution of trees by diameter class is considered important. Thus, the 1/2-acre strip plot is recommended.

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LITERATURE CITED

1. Knight, Fred B. 1958. Methods of surveying infestations of the Black Hills beetle in ponderosa pine. Forest Sci. 4:35-41.

2. Knight, F. B., W. F. McCambridge, and B. H. Wilford. 1956. Estimating Engelmann spruce beetle infestations in the Central Rocky Mountains. USDA Forest Serv., Rocky Mtn. Forest and Range Exp. Sta., Fort Collins, Colorado, Sta. Paper No. 95, 12 p.

3. Larson, R. W., and A. A. Hasel. 1958. A field test of forest survey techniques. North Carolina Southern Piedmont test, May 9, 1958. RE-SE, Forest Survey, Techniques Research, 44 p.

4. Lindsey, Alton A., James D. Barton, and S. R. Miles. 1958. Field efficiencies of forest sampling methods. Ecology 39: 428-444.

5. Shanks, Royal E. 1954. Plotless sampling trials in Appalachian forest types. Ecology 35:237-244.

6. Stage, Albert R. 1962. A field test of point-sample cruising. USDA Forest Serv., Intmtn. Forest and Range Exp. Sta., Ogden, Utah, Res. Paper No. 67, 17 p.

APPENDIX

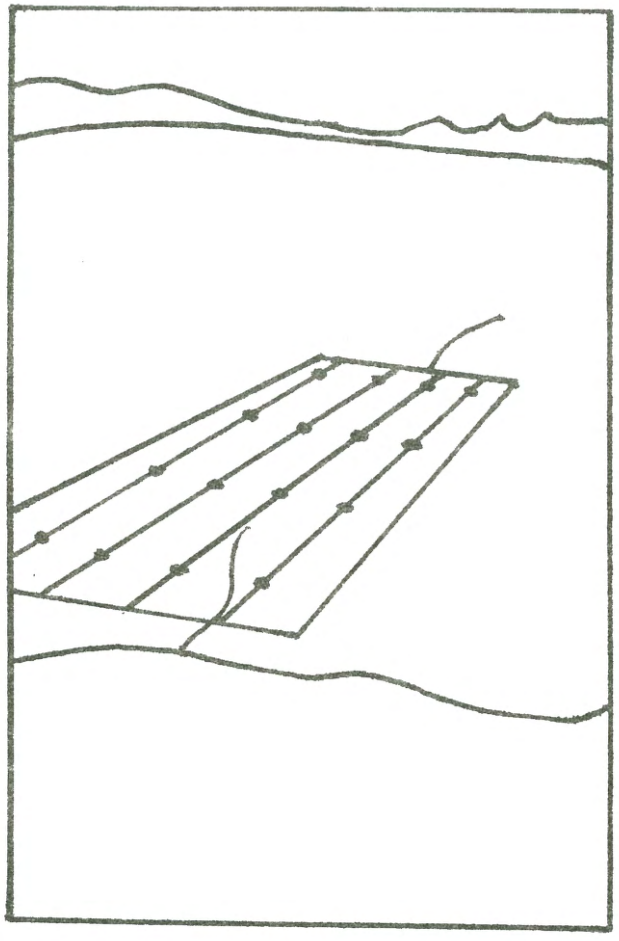

Figure 1. Drawing shows general cruise area boundary and plot layout and the oblique aerial photograph shows the study area (Targhee National Forest, 1972).

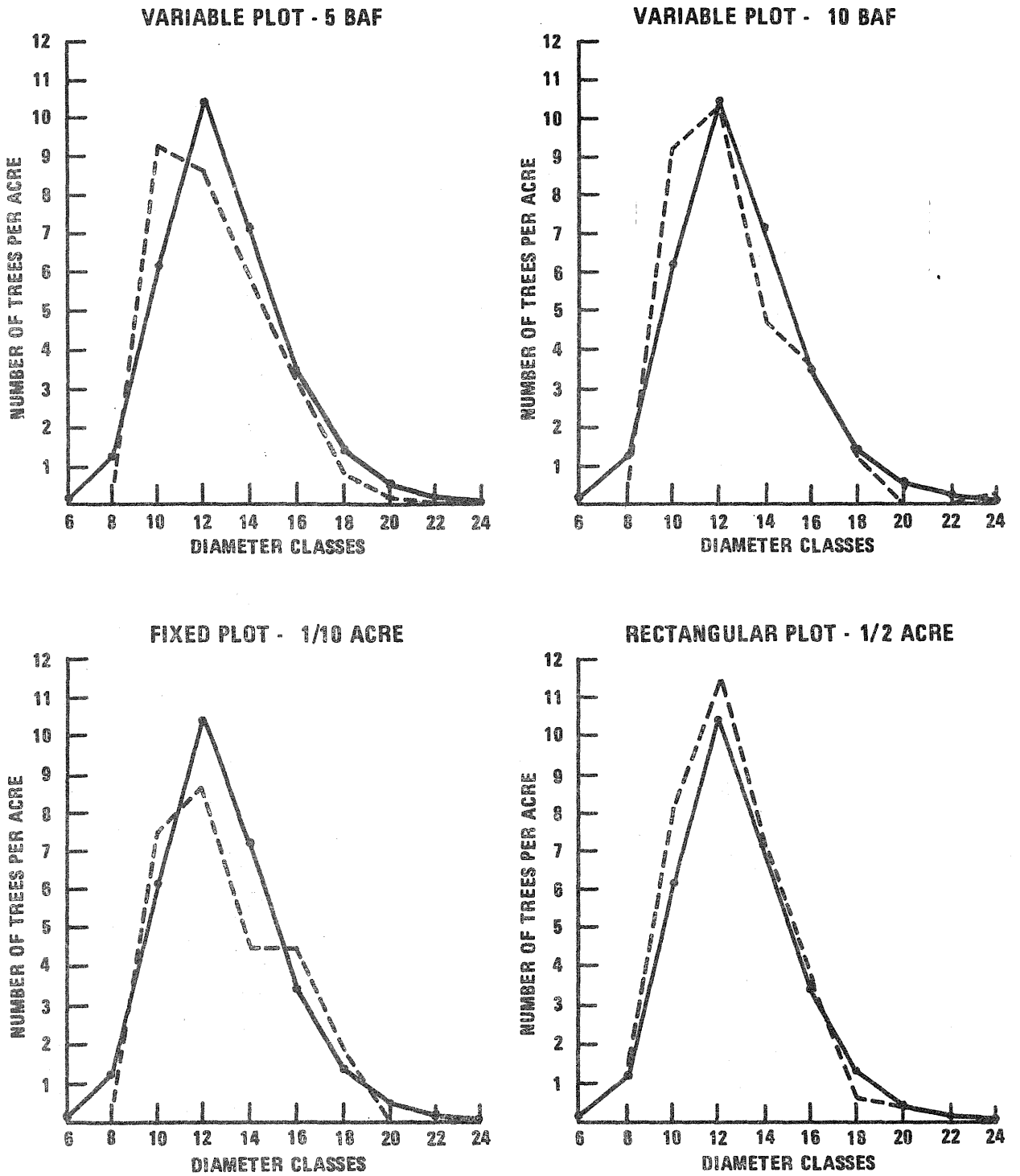

Figure 2. Comparison of diameter distribution estimates for the plots tested (dotted lines) with the results of a "complete inventory" (solid lines); Targhee National Forest, 1972.

Table 1. Statistical estimators of sample populations for the plots tested.

STATISTICAL ESTIMATORS	VARIABLE PLOT 5 BAF	VARIABLE PLOT 10 BAF	FIXED PLOT 1/10-ACRE	STRIP PLOT 1/2-ACRE
Mean	28.25	29.03	26.87	32.50
Standard Deviation	28.35	31.56	28.92	30.04

Table 2. Comparison of average sampling times per tree for the four plots.

PLOT TYPES	AVERAGE NUMBER OF TREES PER PLOT	AVERAGE SAMPLING TIME PER PLOT (MINUTES)	AVERAGE SAMPLING TIME PER TREE (MINUTES)
Variable			
5 BAF	8.55	18.4	2.15
10 BAF	4.66	13.9	3.02
Fixed Radius			
1/10-acre	2.60	15.9	6.12
Strip			
1/2-acre	10.25	20.3	1.98

Table 3. Numbers of trees per acre killed by the mountain pine beetle, Targhee National Forest, 1972.

DBH	VARIABLE PLOT 5 BAF	VARIABLE PLOT 10 BAF	FIXED RADIUS 1/10-ACRE	STRIP 1/2-ACRE	COMPLETE TALLY
6	-	-	-	-	0.10
8	-	-	-	1.25	1.19
10	9.17	9.17	7.50	8.13	6.07
12	8.75	10.34	8.75	11.37	10.36
14	5.85	4.68	4.37	7.00	7.10
16	3.36	3.58	4.37	3.63	3.63
18	0.88	1.06	1.88	0.63	1.51
20	0.14	-	-	0.37	0.45
22	-	-	-	0.12	0.10
24	0.10	0.20	-	-	0.04
Total	28.25	29.03	26.87	32.50	30.55

Table 4. Departures of adjusted trees per acre by diameter class from the complete tally figures.

DBH	VARIABLE PLOT 5 BAF	VARIABLE PLOT 10 BAF	FIXED RADIUS 1/10-ACRE	STRIP PLOT 1/2-ACRE
6	0.10	0.10	0.10	0.10
8	1.19	1.19	1.19	0.06
10	3.10	3.10	1.43	2.06
12	1.61	0.02	1.61	1.01
14	1.25	2.42	2.73	0.10
16	0.00	0.05	0.74	0.00
18	0.63	0.49	0.37	0.88
20	0.31	0.45	0.45	0.08
22	0.10	0.10	0.10	0.02
24	0.06	0.14	0.04	0.04
Total	8.35	8.06	8.76	4.35